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Excimer Gas-Discharge Tunable ArF Laser

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Abstract. Intense laser oscillation has been observed from ArF molecules at 1933 Å. Excitation of the gas mixture NF_3:Ar:He=1:55:630 at total pressures above 2.1 atm was produced by a transverse electric discharge. The range of fine tuning was from 1927 Å to 1936 Å. An output energy of 0.8 mJ was measured from a laser pulse 15 ns in duration.

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Recent works reported on excimer lasers operating on rare-gas monohalides XeF [1, 2], XeCl [3], XeBr [4], KrF [3, 5–7], ArF [8]. Excitation in these systems is brought about by a heavy-current beam of relativistic electrons. Of great practical interest are electric-discharge excimer lasers which afford rather high radiation power and high efficiency. It has been also reported that generation can be achieved through excitation by electric discharge in XeF [8, 9], XeCl [10], KrF [11].
In this paper we discuss an electric-discharge tunable ArF-laser operating in the vacuum ultraviolet.

Experiment

Excited ArF* molecules are formed by the chemical reaction of excited Ar* atoms with the NF_3 molecule. Initially the ArF* molecules are in high vibrational states and, as a result of their collisions with a buffer gas (helium), pass into a lower vibrational level. The lower electron level is repulsive. The operating laser transition is bound-free.
The gas mixture of He, Ar, and NF_3 in the ratio 630:55:1 at the total pressure $2.0 \div 3.5$ atm. was excited by a transverse electric discharge with the help of a Blumline line. A line of size 60×36 cm and capacity $3.8 \cdot 10^{-9}$ F was charged by pulses of up to 30 kv. The laser cell identical in design with that of the VUV H_2-laser [12] was made of glass, its ends tapered at the Brewster angle, the active volume was $36 \times 1.1 \times 0.1$ cm. The active zone pre-ionization by displacement current assures charge stability at a high pressure.
The cavity was formed by a diffraction grating of 1200 line/mm operating in the third order and a plane translucent aluminum mirror with a reflection coefficient of 30%.
A 1 m-spectrograph with a grating of 1200 line/mm and a dispersion of 13 Å/mm was used to measure spectra of spontaneous and laser radiation. The spectra were photographed on UV-2 Schumann film. The iron arc spectrum was used as a reference. The energy of laser radiation was measured with a calibrated thermopile and its duration—with a coaxial photoelement and a time interval meter. The time resolution of the system was not worse than 3 ns.

Results

Figure 1 shows the spectra of spontaneous and laser radiation. The spontaneous radiation spectrum was produced with a mixture pressure of 1.5 atm in a cell without cavity, while the laser radiation spectrum was produced for different positions of the grating. The laser line half-width is 2.5 Å. The range of fine tuning was from 1927 Å to 1936 Å. As the cavity is tuned to the amplification contour peak, the radiation energy equaled 0.25 mJ/pulse. When the diffraction grating

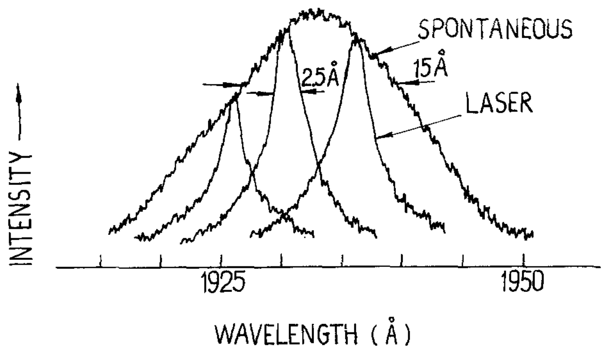

Fig. 1. Spectrum of spontaneous luminescence from a cell without any cavity at 1.5 atm, and spectrum of laser radiation at different positions of the diffraction grating

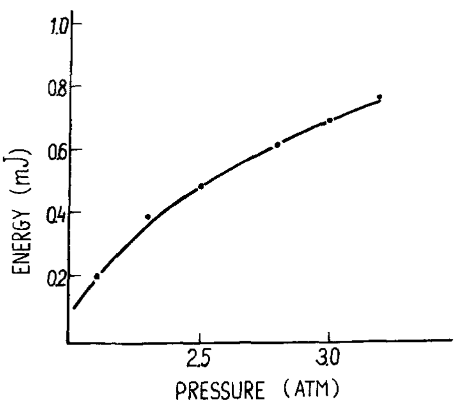

Fig. 2. Dependence of laser radiation energy on active medium pressure. Mixture: NF_3:Ar:He=1:55:630

was replaced by a mirror with the reflection coefficient of 68%, the spectral line half-width increase up to 5 Å and the radiation pulse energy equaled 0.8 mJ. The center of the radiation line falls on 1933 Å. When this radiation passes through air, there are three lines of molecular oxygen absorption observed on the spectrogram.

Figure 2 illustrates how generation energy depends on the active medium pressure. Generation appears only at pressures above 2.1 atm and grows with increasing pressure. Further increase in the pressure, above 3.5 atm, may result in a cell failure.

The pulse half-width was 15 nsec (FWHM). The estimated radiation power equals 50 kW.

The laser operated with a repetition frequency of up to 5 Hz with no decrease in the peak power. To increase the repetition frequency, it is necessary that operating mixture should be pumped at a high rate. For ArF-laser it is easy to increase the pumping rate since all the components of the gas mixture are comparatively cheap in contrast to other excimer lasers operating on rare-gas monohalides such as XeF and KrF.

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